CIRCULAR No. 158 MARCH, 1931
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A SIMPLE CHEMICAL TEST FOR PREDETERMINING THE CULINARY QUALITY OF POTATOES AS AFFECTED BY THE ACCUMULATION OF SOLUBLE SUGARS

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CONTENTS

INTRODUCTION

Recently a company manufacturing potato chips on a large scale wrote to the United States Department of Agriculture that it had no means of ascertaining whether potatoes, as purchased on the market, would make good chips. A simple, quick, and reliable method was needed to determine the quality of potatoes for chip making before buying.

It has been found by plant physiologists (*1*, *2*, *5*, *6*, *7*)[2] that potatoes placed in cold storage at temperatures ranging from 32° to 50° F. accumulate sucrose and reducing sugars such as glucose, levulose, and possibly others, as a result of the hydrolysis of starch. The amount of these soluble sugars appearing in potatoes depends on the temperature and duration of storage and generally becomes greater the lower the storage temperature above the freezing point and the longer the storage period.

As a result of an increase in the concentration of soluble sugars in potatoes stored at low temperatures, the potato chips and French fried potatoes brown before the completion of the cooking process, owing to the breakdown or caramelization of the sugars. Quantitative analyses were made for soluble sugars in Irish Cobbler and Jersey Red Skin varieties previously stored at 32°, 36°, 40°, 50°, and 60° F. for five months. At the same time potato chips were made from this material. The relation between the storage temperature, the amount of soluble sugars, and the extent of browning of the chips was strikingly demonstrated; in general, the lower the storage tem-

[1] The writers wish to acknowledge the cooperation of William Stuart who suggested the problem and the use of Fenling's solution as a reagent.

[2] Italic numbers in parentheses refer to Literature Cited, p. 4.

perature the greater the amount of soluble sugar and the darker the color of the chips.

Moreover, an excessive accumulation of both reducing and nonreducing sugars produces a sweetness in products made from the tubers that is distasteful to many consumers. When mature potatoes are first harvested they possess a natural flavor characteristic of the variety and the conditions under which they are grown. How long they continue to retain this natural flavor depends principally on the time and temperature in storage. Correlated with the rise in sugar content in potatoes stored at low temperatures are other changes not yet fully understood, which seem to affect more or less directly the texture of boiled potatoes and the manner in which oil is taken up in fried potatoes or in potato chips.

Thus, a logical means of predetermining culinary quality in potatoes would consist of a rapid test for the amount of soluble sugars. Since published analyses show that reducing sugars constitute the greater part of soluble sugars in potatoes stored at low temperatures and are always accompanied by the nonreducing sugar sucrose, which generally increases or decreases with reducing sugars, a test for the reducing sugars would obviously answer the purpose.

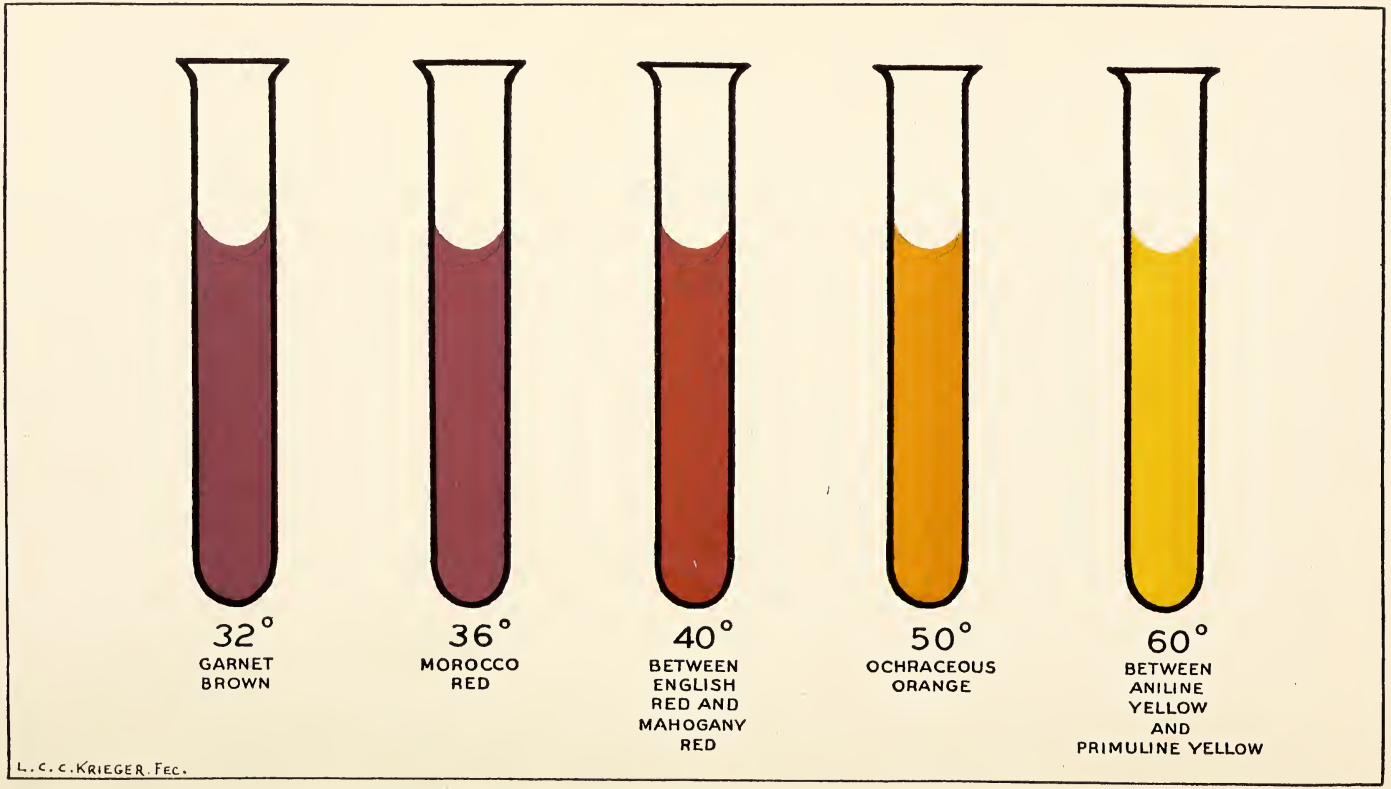
TESTS FOR REDUCING SUGARS

Any of the well-known tests for reducing sugars, such as glucose, may be used. The writers tested for reducing sugars three potato varieties—Jersey Red Skin, Green Mountain, and Irish Cobbler—previously stored at 32°, 36°, 40°, 50°, 60°, and 70° F. for two to six months, using the following reagents: (1) Fehling's solution, (2) Benedict's solution, (3) alkaline methylene-blue solution, and (4) picric-acid solution. In every case excellent differentiation between potatoes held at the various storage temperatures, except those at 60° and 70°, was obtained; at the higher temperatures little or no sugar is present.

With the first two reagents, a precipitate of cuprous oxide (CuO), yellow to brick red in color, is obtained. Alkaline methylene-blue solution is decolorized by reducing sugars, while a yellow solution of sodium picrate is changed to a red solution of sodium picramate. The amount of precipitate of CuO obtained, the extent of the discharge of the color of methylene blue, or the depth of red color produced in sodium-picrate solution, are all proportional to the amount of reducing sugars present, other factors such as time and temperature of heating the solutions and the alkalinity of the solutions being equal.

The picric-acid solution[3] was chosen because it will detect smaller quantities of reducing sugar than will Fehling's or Benedict's solutions. Then, too, slight differences in glucose content can be detected more readily by differences in color than by visually comparing small amounts of cuprous-oxide precipitate. The use of a solution of methylene blue has the disadvantage that after being decolorized by a reducing sugar it more or less completely regains its original color on standing.

[3] The picric-acid method for the determination of reducing sugars in plant material is not new (*3, 4, 8, 9, 10*).



CONTENT OF SOLUBLE SUGARS IN POTATOES STORED AT TEMPERATURES FROM 32° TO 60° F., AS INDICATED BY THE PICRIC-ACID TEST

PREPARATION OF SAMPLE

To obtain comparative results in the picric-acid test for reducing sugars, it is necessary to use approximately the same amount of material in each test. This is most conveniently done by cutting out a cylinder from the center of a potato tuber by means of a cork borer which has an inside diameter of three-sixteenths of an inch. A 1-inch length of the potato cylinder, measured from the skin, is cut off and used for the test. Since there is more sugar at the stem end than at the bud end, it is important that the test cylinders be taken from approximately the center of the tubers to make them comparable. To obtain a correct judgment on the relative amount of reducing sugar in a large lot of potatoes, samples should be taken from a half dozen or more tubers.

TECHNIC OF THE TEST

One cubic centimeter of a saturated aqueous solution of picric acid [4] is placed in a test tube, then 1 cubic centimeter of a 20 per cent sodium carbonate (Na_2CO_3) solution, and last, the potato cylinder. After the contents have been shaken, the test tube is held for one minute over the flame of an alcohol lamp, and then placed in a rack to cool. In Plate 1 are reproduced the colors [5] obtained by testing cylinders from Green Mountain potatoes harvested November 11, 1929, and 10 days later stored at the five temperatures indicated, until March 21, 1930.[6]

The color between aniline yellow and primuline yellow obtained with the picric-acid test from the sample stored at 60° F. showed that reducing sugar was practically absent, while the garnet-brown color obtained from the 32° sample corresponds to the presence of reducing sugars in amounts certain to cause a very poor grade of chips, as determined by an actual cooking test of a portion of the same lot of material.

For crisp, golden-yellow chips or golden-yellow "French fries" the color of the solution after the test should match that on the extreme right of Plate 1. Chips with brown blotches may result when the final color approximates that of the second tube from the right.

DISCUSSION

It is well known that the accumulation of soluble sugars, which occurs in potatoes held at low storage temperatures, is reduced when they are subsequently held at a higher temperature. Manufacturers of potato chips, for example, make a practice of transferring potatoes from the lower storage temperatures to 60° or 70° F. for a short time before using them, or until it is judged that they will make suitable chips.

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[4] This reagent is readily prepared by simply dissolving an excess of picric-acid crystals in boiling water; after cooling, the liquid above the crystals is poured off and is ready for use. To make up a 20 per cent solution of Na_2CO_3, add 200 grams of anhydrous Na_2CO_3 to 1 liter of water (10 ounces to 3 pints of water).

[5] RIDGWAY, R. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 p., illus. Washington, D. C. 1912.

[6] In this experiment 1 cubic centimeter of 0.29 N NaOH (1.16 per cent) was used instead of 1 cubic centimeter of 20 per cent Na_2CO_3. Both reagents will give the same color on the same material, but the intensity of color will be different, depending on the amount of alkali present.

The test described above should make possible not only the selection of more desirable potatoes for chip making but also the more accurate determination of the storage time and temperatures most favorable to the proper conditioning of potatoes for making chips.

SUMMARY

The picric-acid test for reducing sugar, the technic of which has been described, is applicable to the selection of potatoes for chip making, French frying, baking, and under certain conditions for boiling. It is particularly designed to aid potato-chip manufacturers, who must have potatoes with a low content of soluble sugars, and buyers for hotels and restaurants where high-grade cooked potatoes, free from a sweetish taste, are desired.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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